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Report No. 22

EIGHTH
ANNUAL REPORT
OF THE
SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA
1927

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY

EDMONTON:
Printed by W. D. McLean, Acting King's Printer
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ORGANIZATION

The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

Chairman—Hon. J. E. Brownlee, Premier.

H. M. Tory, President, University of Alberta.

J. T. Stirling, Chief Inspector of Mines, Province of Alberta.

J. A. Allan, Geologist.

N. C. Pitcher, Mining Engineer.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

R. M. Young, Canmore, Alberta.

Honorary Secretary—Edgar Stansfield, Chief Chemical Engineer, Industrial Research Department, University of Alberta.

Requests for information and reports should be addressed to the Honorary Secretary, Industrial Research Department, University of Alberta, Edmonton, Alberta.

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University of Alberta,
Edmonton, Alberta,

Hon. J. E. Brownlee,
Premier,
Edmonton, Alberta.

Sir:—

Under instruction from the Scientific and Industrial Research Council of Alberta, I herewith submit their Eighth Annual Report. This covers the work done under their direction during the year ending December 31st, 1927.

Respectfully submitted,
Edgar Stansfield,
Honorary Secretary.

EIGHTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

ORGANIZATION.

In the organization of the University of Alberta the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research laboratories.

In the organization of the Provincial Government the work of the Research Council is attached to the Executive Council.

PERSONNEL AND MEETINGS OF COUNCIL.

Five meetings of the Council were held during the year. The personnel of the Council on December 31st was:

Hon. J. E. Brownlee, Premier, Chairman.

H. M. Tory, President, University of Alberta.

J. T. Stirling, Chief Inspector of Mines, Province of Alberta.

J. A. Allan, Geologist, University of Alberta.

N. C. Pitcher, Mining Engineer, University of Alberta.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

R. M. Young, Canmore, Alberta.

Edgar Stansfield, Chief Chemical Engineer, Honorary Secretary.

STAFF.

The following changes in the permanent staff have been made during the year:

S. M. Blair resigned his position as Assistant Research Engineer, Road Materials, on February 15th.

Nick Melnyk commenced work as Assistant Engineer, Road Materials, in place of S. M. Blair resigned, on May 9th.

J. D. Baird resigned his position as Laboratory Assistant, Fuels, on September 15th.

A. D. Wood commenced work as Laboratory Assistant, Fuels, in place of J. D. Baird resigned, on September 19th.

H. M. Kesner resigned his position as Office Assistant on September 21st.

W. F. McDonald commenced work as Office Assistant, in place of H. M. Kesner resigned, on September 20th.

J. Mooney resigned his position as Laboratory Assistant, Road Materials, on September 24th.

G. Alan Harcourt commenced work as Technical Laboratory Assistant, Road Materials, on November 29th.

The permanent staff on December 31st, 1927, was as follows:

EDGAR STANSFIELD, Chief Chemical Engineer, *Fuels;*

K. A. CLARK, Research Engineer, *Road Materials;*

R. L. RUTHERFORD, Geologist, *Geology;*

W. A. LANG, Assistant Engineer, *Fuels;*

J. W. SUTHERLAND, Assistant Engineer, *Fuels;*

S. ZEAVIN, Assistant Engineer, *Fuels;*

K. C. GILBART, Assistant Engineer, *Fuels;*

NICK MELNYK, Assistant Engineer, *Road Materials;*

G. ALAN HARCOURT, Technical Laboratory Assistant, *Road Materials;*

HAZEL M. WORTMAN, Accountant and Stenographer;

RUTH MACLENNAN, Geological Stenographer;

A. D. WOOD, Laboratory Assistant, *Fuels;*

W. F. MCDONALD, Office Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, members of the Council, are in permanent charge of the Council's research work in Geology and Mining Engineering respectively. Associate Professor A. E. Cameron acts as secretary to the Council and has charge of the office staff.

Other members of the University staff have assisted from time to time; notably Prof. R. S. L. Wilson, who devoted considerable time throughout the year to work for the Council on the forest products of Alberta, with special reference to mine timber.

A number of other persons held summer or short term appointments under the Council:

In the Geology Division: L. S. Russell and Geo. C. Haworth, part time assistants in field work; and O. Inkster and S. K. Jaffary, draftsmen.

In the Road Materials Division: J. V. Lehmann, special laboratory work.

In the Forest Products Division: D. A. Hansen, H. M. Hunter, S. K. Jaffary and E. C. Whittaker rendered occasional service.

LABORATORIES AND EQUIPMENT

The principal items of laboratory equipment purchased or constructed during the year are as follows: Freas vacuum oven, toluol drying oven, laboratory colloid mill, Weston ammeter, Weston wattmeter, Leeds and Northrup potentiometer, Bacharach differential pressure recorder, volumeter for testing mine dusts, furnace for volatile matter determinations, two tube furnaces, apparatus for determination of softening and decomposition temperature of coal, and a work bench in the briquetting laboratory.

FUELS

The work of previous years was continued and some new investigations begun under the supervision of Mr. Stansfield. The outstanding work of the year was that in connection with a study of the coking properties of Alberta coals.

The study of the suitability of Alberta bituminous coals for the manufacture of coke was commenced in February, following a suggestion received from the Alberta Coal Council. Over a million tons of Alberta coal has been coked in the past, so that there is no doubt that good coke can be made. Coals of different variety are available to give denser or lighter coke as desired, also greater or smaller gas yield. The range of choice can be extended, if necessary, by blending coals. The present investigation has not yet passed the laboratory stage, but it has gone far enough to show that Alberta could supply the needs of a Canadian coke industry.

Analytical work on samples received from the Provincial Mines Branch included analyses of 34 samples of coal, 36 of coal dust and 3 of limestone or of shale. Calibration tests were carried out to enable rapid determinations to be made of the combustible matter in coal dust from the Crowsnest Pass area by means of the U.S. Bureau of Mines volumeter.

Good progress was made with the chemical survey of the coals of the Province. This work included proximate and ultimate analyses, determinations of calorific value with varying ash content, of ignition temperature, of oxidisability and of specific gravity of the coal, as well as determinations of the fusibility of the ash from the coal. No change was made in the regular methods of sampling and analysis, but an improvement was made in the determination of carbon and hydrogen. In the special tests referred to a considerable portion of the work consisted in improving and standardising some of the methods employed. The information collected in the chemical survey of Alberta coals is being carefully compiled and studied in relation to existing or possible coal classification. Neither Canada nor the United States has as yet any generally accepted system for the classification of their coals; but in both countries representative bodies have this subject under consideration.

Little progress was made with the work of domestic heaters, but a local design of hot air furnace to burn natural gas was tested, as was also a fuel economizer. No further work was done on residence heating.

The briquetting investigation was continued. For the first time a comparison could be made of the briquettes made in the experimental plunger type press and in a small commercial roll type press. Lignite coal was carbonised and briquetted, and colloidal and other special binders were tried. Altogether 94 batches of briquettes were made. The results of the last few years have been reviewed, and tables prepared showing a number of the better quality batches of briquettes with different types of coals and of binders. All those included are regarded as being of at least fair commercial value, and many of them are excellent.

A more detailed report of the several branches of the work on fuels is given as an appendix.

GEOLOGY

The work of the Geological Survey Division of the Council is carried on in conjunction with the Department of Geology at the University of Alberta, under the direction of Dr. J. A. Allan. The palaeontological material obtained on field surveys is determined by Dr. P. S. Warren, and in return for this co-operation, Dr. R. L. Rutherford assisted in teaching in the Department of Geology. Mr. L. S. Russell determined the fossil vertebrates that were obtained from the geological surveys.

The office was open throughout the entire year. The correspondence in connection with the mineral resources was heavier than in the previous year and requests for information were equally varied in character. As the work involved in drafting of maps and charts increased, it was necessary to employ a draftsman for approximately two and one-half months.

Two geological reports and one map were published by the Council. One additional report on the Sounding Creek district was prepared by Dr. Allan and published as an appendix to a Soils Survey Report printed by the Department of Extension.

A black and white outline map and a chart with a special report on "Natural Gas" were prepared and published in Report No. 20 of the Council.

One geological survey party under Dr. Rutherford spent about four months in different parts of the province. Dr. Warren accompanied Dr. Rutherford on the western end of the Bow section and on the Elbow river. Dr. Allan and Dr. Rutheford collected geological information in the Lethbridge coal mines and the Crowsnest pass in the early part of the season. They examined the geology of the Rochester coal area and north to Athabaska Landing. In September a preliminary survey was made of the geology in the vicinity of Grande Prairie and Spirit River.

Dr. Allan edited the reports and maps prepared by this division during the year . He also compiled additional data on some of the mineral resources of Alberta for the Hon. Herbert Greenfield, who is in charge of the London office of the Alberta Government.

An appendix to this report gives the scope of the work carried out by the Geological Survey Division during the year 1927.

ROAD MATERIALS

Two reports, entitled Bituminous Sands of Alberta, Parts I and II, were published during 1927. Part I describes field work done in the bituminous sand area, gives the results of analyses of samples and discusses results. Part II deals with the development of a hot water separation process to semi-commercial scale, and laboratory studies of specific features of the process, with an estimate of the cost of producing separated bitumen. The results of cracking tests on the bitumen by the Universal Oil Products Company are included.

Since some form of bituminous treatment may be introduced into Alberta to protect the gravel roads from the rapidly growing motor traffic, it was considered of importance to investigate the usefulness of the extracted bitumen for this purpose, and a 600 foot experimental stretch of bituminized gravel road was built during the summer. The bitumen was emulsified to overcome its viscosity and to make it fluid enough to mix with gravel readily at ordinary temperatures.

The use of emulsion in the road experiment made necessary a study of emulsification of asphaltic oils. To gain a wider experience in the art, one ton of asphalt flux was emulsified for the Engineering Department of the City of Edmonton, who used it as a waterproofing coat of asphalt to green concrete in the new 109th street subway. The emulsion was easily and cheaply applied, and the resulting bituminous protective coat adhered tenaciously. The city supplied the asphalt flux and the required stabilizing reagents, and in exchange for the work of making the emulsion, the Engineering Department placed a concrete mixer at the disposal of the Research Department for mixing gravel and emulsion for its road experiment.

Dr. Clark and N. Melnyk spent September in the bituminous sand area along the Athabaska river. Features of the bituminous sand deposits were studied, private parties working in the area were visited, and a quantity of specially chosen bituminous sand for experimental work was secured.

FOREST PRODUCTS

The work outlined in the 1923 report was contiued during the year by Professor R. S. L. Wilson. Tests are almost completed on the lodge pole pine and compilation of results is progressing. Further particulars of this work will be found in the appendix.

MISCELLANEOUS

On April 27th, Dr. Allan addressed the Women's Canadian Club of Calgary on the subject of the petroleum situation in Alberta.

In April, J. A. Allan, N. C. Pitcher, R. Rutherford and E. Stansfield visited coal mines in Lethbridge and the Crowsnest Pass.

On May 23rd, Mr. Stansfield presented a paper to the Edmonton branch of the Canadian Institute of Mining and Metallurgy entitled "Coking Alberta Coals."

In September, Dr. Cameron represented the Council at the meetings of the Empire Mining and Metallurgical Congress at Jasper.

On December 8th and 16th respectively, addresses were given by Dr. Allan to the Calgary Branch of the Engineering Institute of Canada on "Geology of the Foothills in Relation to Petroleum," and to the Calgary Board of Trade on "Canada's Sleeping Partner." These addresses referred to the position of the petroleum industry in relation to the balance of trade in Canada.

During the year radio talks on technical subjects were broadcast by Dr. Allan and by Dr. Clark from the University Extension Department's radio studio.

During the year short reports were prepared on "The Petroleum Industry in Alberta" for the Hon. Herbert Greenfield, London, England, and on "The Petroleum Situation in Alberta" for special mining editions of the Toronto Globe and the Financial Times.

ACKNOWLEDGMENTS.

Appreciation is expressed to all those who have given assistance in carrying through the work of the year.

The Department of Railways gave permission for the carrying out of work at the site of the separation plant at the Dunvegan Yards, and for the erection of needed structures adjacent to it. The good will and assistance of officials at the railway shops and yard facilitated the experimental work greatly.

The Department of Public Works granted permission for the use of a section of roadway on the St. Albert Trail for experimental road work. It also arranged to have a power maintenance grader and operator sent to the St. Albert Trail at the appropriate time for use in connection with the experimental work. The interest and co-operation of the engineers of the Department was much appreciated.

FUELS DIVISION

By E. STANSFIELD, W. A. LANG, J. W. SUTHERLAND, K. C. GILBART AND S. ZEAVIN.

Prof. N. C. Pitcher, Chief Mining Engineer, assisted with suggestions and advice with most of the work described.

The entire staff worked on the coking properties of Alberta coals for several months during the earlier part of the year. This work was continued by K. C. Gilbart (with some interruptions) throughout the year. W. A. Lang continued the briquetting investigations, particularly with reference to carbonized lignite and colloidal binders. J. W. Sutherland continued his work as fuel analyst, he made a study of chemical and physical properties of fifteen coals in considerable detail. K. C. Gilbart, in addition to work on coke, worked on the determination of the specific gravity of coals and made a few tests with domestic furnaces. S. Zeavin carried out mine dust analyses and fuel analyses and he made some special chemical and physical tests on a small number of coals.

COALS TESTED.

No carload samples were received for test. Seven tons of Edmonton and Coalspur coal were purchased for use in briquetting tests and in domestic heater tests.

Provincial Mine Inspectors submitted 34 coal, 36 coal dust, and 3 limestone or shale samples. Coal operators supplied 12 coal samples for coking tests and 7 miscellaneous samples for test. Four other samples were obtained for coking tests, and 7 other miscellaneous samples were received.

The coal samples came, 24 from Kootenay horizon, 9 from Belly River horizon and 17 from Edmonton horizon mines. Samples have now been analysed from 278 mines in the Province.

SAMPLING AND ANALYSES.

No change has been made during the year in the regular methods of sampling and analysis.

In the Annual Report for 1925, p. 16, it was stated that a Dennstedt apparatus for the ultimate analysis of carbon and hydrogen in coal had been set up and tested against the more usual Liebig apparatus, but that it was not found to be as satisfactory as the latter. During the year a new method was devised for carrying out this analysis and the apparatus was set up in place of the Dennstedt apparatus. The new system was found to be both quicker and more reliable than either of the older systems. At present all samples are analysed in duplicate, one in the Liebig and one in the new apparatus.

CHEMICAL SURVEY OF ALBERTA COALS.

In the Annual Report for 1926 it was stated that as the approximate composition of the coals from all the important producing areas was known, a more detailed study was begun towards the close of that year. Full ultimate analyses were made on 7 coals in 1926 and 22 coals in 1927. More detailed studies were made on 4 coals in 1926 and 15 in 1927.

Some details of this work are given in the following section, full reports of each coal tested will be supplied to the operator of the mine in question.

CLASSIFICATION OF ALBERTA COALS.

The information available from proximate, ultimate and special analyses of Alberta coals is being carefully studied and tabulated with reference to all existing or suggested methods of classifying coal. The problem of the classification of coal, both for scientific and for commercial purposes, is at present under consideration by representative bodies both in Canada and the United States. The above information is being collected and studied in an effort to guard Alberta's interests in this matter.

IGNITION TEMPERATURE OF COAL.

This work was continued during the year, following the method described in the Annual Report for 1926, p. 16. The tests made include a determination of the ignition temperature of the original coal, and of this coal after it has been exposed to a current of air at 105°C for six hours. The latter determination always gives the higher result.

A study of the figures obtained show a relation between the oxygen content of the coal and its ignition temperature. In general the higher the oxygen content, the lower the ignition temperature. It might be anticipated that the less the ignition temperature of the coal changed during its exposure to the current of air at 105°C, the less liable it would be to spontaneous combustion. Little evidence has yet been obtained on this subject, but it may be noted that the lower the original ignition temperature, the more susceptible the coal is to change by oxidation.

Table I gives the ignition temperature of 28 coals, before and after heating in air. The table also shows total oxygen content, proximate analysis and calorific value of these coals on the basis of coal as mined.

CALORIFIC VALUE CURVES FOR COALS.

Under the heading "Comparison of Coals" in the Third Annual Report of Council, 1922, p. 29, a method was described for determining how the calorific value of any coal varied with its ash content. The coal sample is separated into six or seven fractions of varied ash content, by means of solutions of suitable specific gravity in which clean coal will float and dirty coal sink. The calorific values and ash content of the different fractions are determined and curves plotted to show their relation—both values calculated to a dry coal basis.

TABLE I.—IGNITION TEMPERATURE OF COAL.

Sample No.	Ignition Temperature		Analysis of Coal as Mined					
	Fresh Coal °C	Oxidised Coal °C	Total Oxygen %	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Calorific Value BTU/lb.
(a) Bituminous Coals.								
62.27	235.0	234.5	3.7	1.0	12.0	14.7	72.3	13,420
69.27	232.5	....	3.4	0.9	7.5	15.8	75.8	14,270
74.27	225.5	....	5.4	2.1	6.7	21.8	69.4	14,300
405.27	223.0	226.5	3.3	1.0	12.7	16.4	69.9	13,550
65.27	222.5	223.0	5.0	2.2	8.0	21.5	68.3	14,100
2.28	220.8	....	5.6	1.3	15.1	22.2	61.4	12,700
76.27	217.0	215.3	6.0	1.4	14.0	25.3	59.3	13,020
1.28	216.0	....	6.8	1.3	15.4	25.9	57.4	12,560
404.27	214.0	....	5.3	0.9	9.6	24.6	64.9	13,900
406.27	213.5	....	6.9	0.7	6.6	22.7	70.0	14,110
87.26	212.5	214.2	7.9	3.6	10.0	22.8	63.6	13,350
414.27	211.5	....	5.8	1.4	8.3	27.9	62.4	14,020
402.27	208.5	212.0	7.2	1.2	11.3	29.1	58.4	13,340
78.27	207.3	....	6.6	1.1	9.6	30.4	58.9	13,800
411.27	207.0	....	7.5	1.4	11.1	29.7	57.8	13,530
*407.27	205.3	....	6.8	1.2	6.6	33.5	58.7	14,190
(b) Sub-bituminous Coals.								
53.27	184.0	193.3	14.1	7.2	13.9	34.9	44.0	11,470
86.26	178.5	188.5	20.2	10.6	8.3	35.7	45.4	11,270
(c) Domestic Coals.								
94.26	175.8	187.1	22.7	14.3	11.4	30.4	43.9	10,140
104.26	172.3	190.8	24.5	15.1	10.2	31.4	43.3	10.060
80.27	166.8	189.5	28.8	19.0	13.8	26.5	40.7	8,550
5.27	165.2	185.2	29.2	17.9	4.7	29.7	47.7	10,220
56.27	163.8	183.5	26.5	16.0	8.8	29.1	46.1	9,860
13.27	162.3	....	29.7	18.3	9.8	31.1	40.8	9,260
22.27	161.5	180.0	28.6	19.5	6.2	30.7	43.6	9,710
20.27	160.5	181.5	31.7	20.2	5.6	31.2	43.0	9,440
58.27	157.7	183.3	35.6	25.8	4.9	29.2	40.1	8,870
3.27	157.5	183.3	29.0	17.9	3.5	31.4	47.2	10,420

*Coal from West Virginia.

In order to gain further indication of the comparative resistance of the different coals to weathering or oxidation, samples of the same coals are exposed for six hours to a current of air at 105°C and then separated into fractions by heavy solutions and analysed as with the fresh coals. The calorific values of the oxidised coals are always, for any ash content, lower than the corresponding values

TABLE II.—CALORIFIC VALUE RELATION OF COAL.

Sample No.	Analysis of Coal as Mined					Calorific Value of Dry, Fresh Coal, BTU/lb.					Ash Content for zero calorific value	Reduction of calorific value by oxidation %
	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Calorific Value BTU/lb.	0% Ash	5% Ash	10% Ash	15% Ash	20% Ash		
(a) Bituminous Coals.												
65.27	2.2	8.0	21.5	68.3	14,100	15,940	14,990	14,030	13,080	12,020	83.2	0.8
74.27	2.1	6.7	21.8	69.4	14,300	15,920	14,970	14,020	13,090	12,160	84.3	0.8
76.27	1.4	14.0	25.3	59.3	13,020	15,770	14,870	13,940	13,020	....	85.5	0.5
2.28	1.3	15.1	22.2	61.4	12,770	15,770	14,830	13,900	12,970	12,020	84.2	....
87.26	3.6	10.0	22.8	63.6	13,350	15,750	14,860	13,970	13,070	....	87.6	1.1
69.27	0.9	7.5	15.8	75.8	14,270	15,700	14,810	13,920	13,030	....	88.9	0.4
62.27	1.0	12.0	14.7	72.3	13,420	15,660	14,780	13,890	13,020	....	89.2	0.3
78.27	1.1	9.6	30.4	58.9	13,800	15,560	14,710	13,880	13,030	....	92.0	0.8
(b) Sub-bituminous Coals.												
53.27	7.2	13.9	34.9	44.0	11,470	14,880	14,070	13,260	12,450	11,650	91.8	1.6
86.26	10.6	8.3	35.7	45.4	11,270	14,190	13,330	12,490	11,640	....	83.8	2.5
(c) Domestic Coals.												
94.26	14.3	11.4	30.4	43.9	10,140	13,900	13,130	12,380	11,640	10,890	93.9	2.7
104.26	15.1	10.2	31.4	43.3	10,060	13,720	13,010	12,310	11,600	10,890	96.9	3.1
3.27	17.9	3.5	31.4	47.2	10,420	13,420	12,610	11,810	11,000	....	82.5	3.9
5.27	17.9	4.7	29.7	47.7	10,220	13,370	12,580	11,810	11,030	....	85.7	3.2
22.27	19.5	6.2	30.7	43.6	9,710	13,300	12,570	11,840	11,120	....	91.5	3.1
13.27	18.3	9.8	31.1	40.8	9,260	13,220	12,510	11,790	11,070	....	91.6	3.9
56.27	16.0	8.8	29.1	46.1	9,860	13,210	12,530	11,830	11,150	....	96.6	2.0
20.27	20.2	5.6	31.2	43.0	9,440	13,120	12,330	11,550	10,870	....	83.2	2.1
80.27	19.0	13.8	26.5	40.7	8,550	13,070	12,320	11,600	10,870	10,130	88.9	2.1
58.27	25.8	4.9	29.2	40.1	8,870	13,010	12,240	11,480	....	....	85.8	2.7

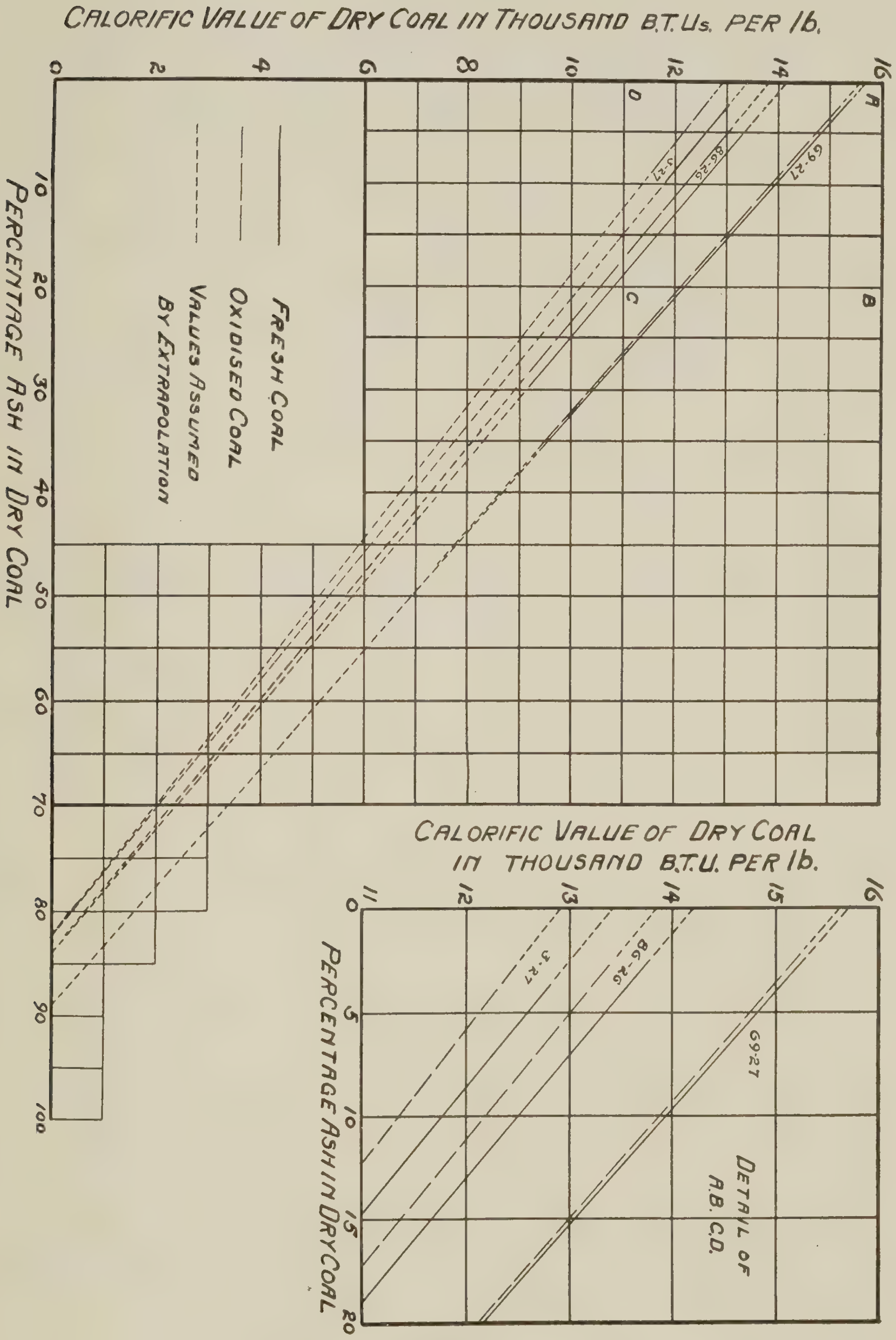

CALORIFIC VALUE OF DRY COAL IN THOUSAND B.T.Us. PER lb.
0
2
4
6
8
10
12
14
16
PERCENTAGE ASH IN DRY COAL
10
20
30
40
50
60
70
80
90
100
FRESH COAL
OXIDISED COAL
VALUES ASSUMED BY EXTRAPOLATION
A
B
C
D
3·27
86·26
69·27
CALORIFIC VALUE OF DRY COAL IN THOUSAND B.T.U. PER lb.
11
12
13
14
15
16
PERCENTAGE ASH IN DRY COAL
0
5
10
15
20
3·27
86·26
69·27
DETAIL OF A.B.C.D.

Figure 1.

of the fresh coal. The percentage reduction is taken as a measure of the oxidation undergone.

Table II shows the proximate analysis and calorific value of 20 coals. It also shows the calorific value of the dry fresh coals with ash content varying from 0 to 20%, the ash content for zero calorific value, and the percentage reduction of calorific value when the coal is oxidised for 6 hours as described below. These latter values are taken from the curves plotted. As in all samples of Alberta coals yet examined the relation between calorific value and ash gives a straight line, anyone interested may plot the curves for these coals from the values given. The ash content corresponding to zero calorific value depends on the chemical nature of the shale or other ash producing impurity in the coal.

Figure 1 gives three typical calorific value-ash curves. These are for one bituminous, one sub-bituminous, and one domestic coal, respectively. The main curves show the whole range from pure coal down to zero calorific value as given by extrapolation. Inset are more detailed curves for the range 0 to 20% ash.

MATURITY OF COAL.

The work referred to in the Annual Report for 1926, p. 17, has been continued. Briefly, the method employed is as follows: Crushed coal is ground in a ball mill filled with natural gas to prevent oxidation. From time to time it is screened through a 200 mesh screen and the oversize returned to the mill for further grinding, until all passes the screen. In this manner a reasonably uniform sized product is obtained with all coals. If the oversize coal were discarded, the harder particles of the coal sample would be excluded from the test. A two gram portion of the ground coal is wet with 50 cc. of a solution of 1 part of caustic potash in 5 parts of water and rapidly heated to boiling—15 minutes total heating. It is then cooled with a small addition of distilled water, filtered with suction through hardened filter paper, washed and made up to 100 cc. To 10 cc. of this solution is added 20 cc. of one-tenth normal potassium permanganate solution and 20 cc. of five normal phosphoric acid solution, in the order stated. The mixture is heated rapidly to boiling in a small flask provided with a reflux air condenser, and a gentle boiling continued for a total time of heating of one hour. The flask is cooled under the tap, 20 cc. of one-tenth normal ferrous ammonium sulphate solution added, and the mixture back titrated at once with the permanganate solution. A blank is run with each test and oxidation and titration are carried out in duplicate. The final results are expressed as grams of oxygen required to oxidise one kilogram of coal as mined, and also to oxidise one kilogram of pure, dry coal substance.

During the year the value of this test has been confirmed, as it is a more sensitive test than, for example, the determination of volatile matter. Its full value cannot be ascertained until more coals have been tested.

Table ~~III~~ IV shows the ordinary analysis of some 20 coals, together with the oxygen absorption values determined as above. Determinations were also made on the same coals, after these had been exposed to a current of air at 105°C for six hours; but these results have been omitted from the table. The oxidisability of a coal, as measured by this test, increases with oxidation in hot air. In the same way a weathered coal gives a higher value than a fresh coal from the same mine. It will thus be seen that as a coal matures from lignitic to anthracitic character its oxidisability decreases, but if coal of any character becomes weathered its oxidisability increases, and its apparent maturity decreases.

SPECIFIC GRAVITY OF COAL.

Determinations have been made of the specific gravity of a number of coal samples. The samples were separated by hand into portions of differing cleanliness, where this was possible, and the specific gravity and analysis of each portion determined. In some cases samples of bone coal were also tested in order to get a wide range of ash content.

Two specific gravities are reported, "apparent" and "real". A lump of coal normally contains many microscopic cells filled with air or gas. The apparent specific gravity is the specific gravity of the lump as it occurs. The real specific gravity is that of the coal substance. The apparent specific gravity is the value to be employed for calculating the weight of a cubic foot of coal as mined and for similar practical applications, but as the real specific gravity can be determined with the greater accuracy, both values are given. The relation between the two values is an indication of the porosity of the coal, the greater the difference between the two values the greater the porosity.

The mineral impurities in a coal are denser than the coal substance, so that, with a few exceptions noted below, the density of any coal increases with the ash. In the table of values reported a number of minor discrepancies will be noticed where a slight increase in ash is accompanied by a decrease in specific gravity. This may be due to a variation either in the coal or in the mineral impurity. It has been noted that with certain coals there is a minimum specific gravity with approximately 3 or 4 per cent. of ash. From this point the density increases with either an increase or a decrease of the ash. It is probable that these extremely low ash samples of coal are largely vitrain and contain little or no fusian or animal charcoal.

The specific gravity changes not only with the ash content of the sample but also with its moisture content. When a lump of high moisture coal dries out the lump shrinks and checks, but it also becomes more porous, so that the apparent specific gravity decreases. No data has yet been collected to correlate the apparent specific gravity of a sample with its moisture content. On the other hand, as the moisture which escapes has a specific gravity of unity and the dry coal substance has a specific gravity of about 1.3 the more the sample dries out the higher its real specific gravity becomes. It has not yet been possible to determine the change of real specific gravity over a wide range of moisture content, but within narrow limits it can be assumed that a decrease of 1% in the moisture content will increase the real specific gravity 0.004 with samples of 1.3 specific gravity, and 0.006 with samples of 1.4 specific gravity.

The results reported in Table III show the moisture and ash content of each portion tested, as well as the determined specific gravities. Slight adjustments have been made in the reported real specific gravities to adjust these values to the same moisture content as for the reported apparent specific gravities. It is hoped eventually to prepare curves showing the relations between the moisture and ash and the specific gravities of different samples of a series of typical coals of the province, but too few determinations have so far been made.

A number of determinations were made of samples taken in 1927, but as the technique of the determination was subsequently improved, the only values reported in the table are those of samples taken early in 1928.

TABLE III.—SPECIFIC GRAVITIES OF COAL AND BONE COAL.

Sample No. Mine and Area	Moisture %	Ash %	Specific Gravity	
			Apparent	Real
(a) Bituminous Coals.				
14.28	1.2	4.6	1.289	1.319
Mountain Park	1.1	4.9	1.279	1.325
Mountain Park Area	0.6	6.4	1.289	1.342
13-28	0.9	7.4	1.329	1.360
Blue Diamond	1.0	7.7	1.326	1.351
Brule Area	0.8	11.2	1.385	1.415
17-28	1.1	3.0	1.306	1.333
Dennison	1.2	10.9	1.378	1.397
Crowsnest Area	0.8	29.6	1.583	1.625
305-28	5.8	1.9	1.328	1.371
Christine	5.2	2.8	1.344	1.386
Crowsnest Area	6.6	5.9	1.365	1.401
(b) Sub-bituminous Coals.				
304-28	7.2	5.1	1.335	1.387
Saunders Ridge	7.3	6.9	1.363	1.389
Coalspur Area	6.9	9.2	1.393	1.424
313-28	9.1	3.3	1.334	1.357
Alexo Mine	7.1	5.0	1.317	1.350
Saunders Area	7.4	12.1	1.385	1.424
314-28	5.5	4.1	....	1.326
Du Rocher	6.0	5.0	1.312	1.343
Pekisko Area	6.3	11.5	1.409	1.439
18-28 & 316-28	4.3	7.5	1.319	1.333
Rhodes Mine	4.1	9.3	1.332	1.358
Pincher Area	4.2	13.9	1.359	1.380
	4.7	17.2	1.384	1.414
	5.1	21.0	1.424	1.453
312-28	5.8	7.2	1.351	1.384
Beazer	5.6	8.1	1.357	1.395
Magrath Area	5.2	11.4	1.381	1.422
301-28	10.3	5.1	1.321	1.355
Lethbridge	9.2	5.8	1.324	1.338
Lethbridge Area	10.5	10.6	1.366	1.381
21-28	10.2	6.0	1.329	1.346
Galt	11.9	10.9	1.378	1.400
Lethbridge Area	12.5	11.6	1.360	1.380
	10.0	12.8	1.388	1.406

(c) Domestic Coals.

Sample No. Mine and Area	Moisture %	Ash %	Specific Gravity Apparent	Specific Gravity Real
308-28	15.0	6.2	1.338	1.366
Bridge End	14.7	7.0	1.354	1.378
Taber Area	14.2	7.4	1.356	1.383
309-28	24.8	3.6	1.309	1.327
Anon	20.3	5.9	1.331	1.358
Taber Area	19.6	8.3	1.345	1.394
311-28	14.1	3.8	1.325	1.348
Aborn	12.7	7.0	1.342	1.364
Milk River Area	12.2	16.1	1.430	1.461
310-28	20.9	4.1	1.312	1.324
Hughson	19.1	7.4	1.347	1.381
Milk River Area	17.8	10.6	1.393	1.411
307-28	17.6	3.8	1.322	1.361
Pembina	18.3	5.2	1.340	1.370
Pembina Area	17.7	7.1	1.351	1.392
324-28	24.9	4.3	1.311	1.325
Cardiff	27.4	4.8	1.298	1.317
Edmonton Area	25.2	5.0	1.315	1.328
	21.1	15.0	1.385	1.397
319-28	24.2	3.9	1.286	1.331
Black Diamond	22.6	8.0	1.337	1.360
Edmonton Area	21.5	8.8	1.332	1.362
318-28	26.4	3.1	1.281	1.320
Dobell	25.2	3.8	1.274	1.325
Tofield Area	24.8	7.4	1.318	1.343
317-28	24.1	4.4	1.300	1.332
Stoney Creek	23.8	5.2	1.316	1.343
Camrose Area	......	......	....	....
320-28	27.0	7.2	1.332	1.349
O.K.	24.1	12.6	1.360	1.378
Castor Area	25.5	16.3	1.402	1.415
306-28	25.0	4.8	1.305	1.332
New Walker	26.3	5.3	1.309	1.335
Sheerness Area	25.4	9.9	1.339	1.362
323-28	18.8	4.3	1.329	1.369
Carbondale	18.0	7.8	1.336	1.396
Ardley Area	17.2	9.0	1.352	....
	19.6	8.8	....	1.403
322-28	19.9	3.4	1.328	1.354
Big Valley	21.9	5.6	1.331	1.355
Big Valley Area	......	......	....	....
321-28	14.1	7.4	1.348	1.380
Carbon Black	15.7	7.8	1.351	1.375
Carbon Area	14.4	8.0	1.352	1.376
302-28	19.5	2.3	1.320	1.340
Elgin	19.6	3.8	1.314	1.336
Drumheller Area	19.4	4.0	1.315	1.336
19-28	17.4	3.5	1.308	1.331
Hy Grade	17.0	3.7	1.309	1.333
Drumheller Area	16.4	15.4	1.398	1.417
	16.0	22.7	1.454	1.472
303-28	18.9	3.2	1.319	1.342
Midland	18.3	7.0	1.333	1.353
Drumheller	18.3	7.6	1.335	1.354
16-28	12.2	5.3	1.336	1.363
Popovich and Vanbesien	12.5	5.7	1.342	1.368
Champion Area	12.8	6.0	1.347	1.368
315-28	13.4	6.9	1.356	1.376
Ellis	......	......	....	....
Champion Area	......	......	....	....

Coking of Alberta Coals.

Coke made in modern, by-product recovery, coke ovens is growing in favour as a domestic fuel, particularly as a substitute for high-priced anthracite. Two such modern plants have been erected in Canada during the past four years, to supply coke to the domestic market, and further plants are sure to follow. A study of the suitability of Alberta bituminous coals for the manufacture of coke has therefore become advisable, and this was commenced in February at the suggestion of the Alberta Coal Council.

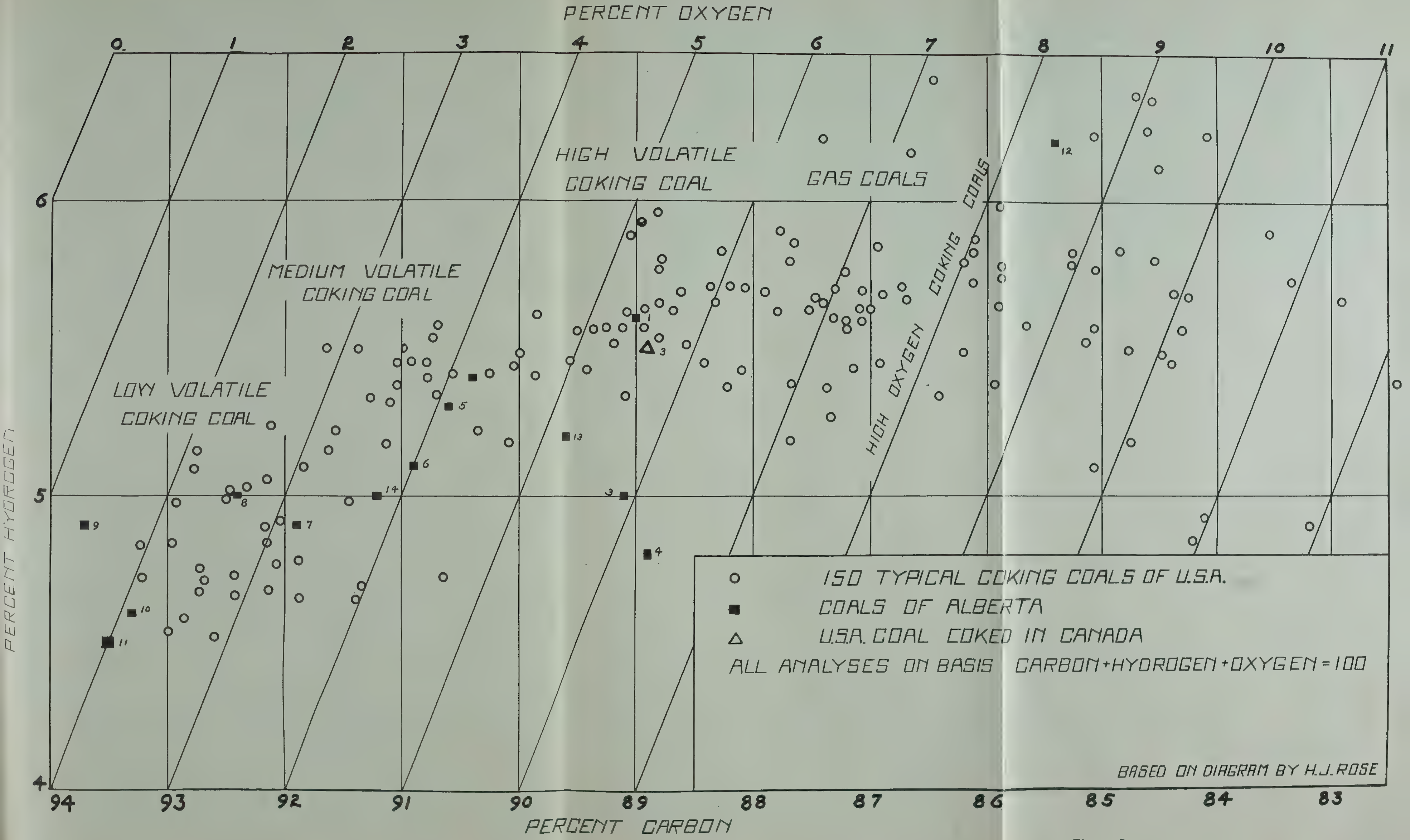
TABLE IV.—MATURITY OF COALS.

Sample No.	Analyses of Coals as Mined						Pure, dry coal
	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Calorific Value BTU/lb.	Oxygen absorbed per kilo coal, gms.	Oxygen absorbed per kilo coal, gms.
(a) Bituminous Coals.							
69.27	0.9	7.5	15.8	75.8	14,270	1.2	1.3
62.27	1.0	12.0	14.7	72.3	13,420	1.1	1.3
78.27	1.1	9.6	30.4	58.9	13,800	1.9	2.1
87.26	3.6	10.0	22.8	63.6	13.350	2.1	2.5
74.27	2.1	6.7	21.8	69.4	14,300	3.4	3.8
65.27	2.2	8.0	21.5	68.3	14,100	3.7	4.2
76.27	1.4	14.0	25.3	59.3	13,020	3.5	4.2
(b) Sub-bituminous Coals.							
53.27	7.2	13.9	34.9	44.0	11,470	10.0	12.9
86.26	10.6	8.3	35.7	45.4	11,270	20.5	25.6
(c) Domestic Coals.							
94.26	14.3	11.4	30.4	43.9	10.140	20.8	28.4
5.27	17.9	4.7	29.7	47.7	10,220	26.7	34.7
56.27	16.0	8.8	29.1	46.1	9,860	37.2	36.6
104.26	15.1	10.2	31.4	43.3	10.060	26.9	38.3
22.27	19.5	6.2	30.7	43.6	9,710	28.5	38.7
80.27	19.0	13.8	26.5	40.7	8,550	27.9	42.5
3.27	17.9	3.5	31.4	47.2	10,420	35.3	45.1
20.27	20.2	5.6	31.2	43.0	9,440	34.4	46.8
58.27	25.8	4.9	29.2	40.1	8,870	37.5	54.6

Between 1905 and 1918, or until the market was lost at the close of the war, over 500 coke ovens were operated in Alberta, coking Alberta coal. Coke has also been made from Alberta coal in gas retorts and coke ovens in Alberta and British Columbia. In all, over a million tons of Alberta coal has been coked in ovens of several different types.

Box Tests.

The final proof of the suitability of a coal for use in any plant is a large scale test of the coal in a commercially operated oven of the type installed in that plant. The box test, however, which is comparatively easy to carry out, can give a good indication of the



PERCENT OXYGEN
0. 1 2 3 4 5 6 7 8 9 10 11
PERCENT HYDROGEN
6 5 4
PERCENT CARBON
94 93 92 91 90 89 88 87 86 85 84 83
HIGH VOLATILE COKING COAL
GAS COALS
MEDIUM VOLATILE COKING COAL
LOW VOLATILE COKING COAL
HIGH OXYGEN COKING COALS
1 3 4 5 6 7 8 9 10 11 12 13 14
○ 150 TYPICAL COKING COALS OF U.S.A.
■ COALS OF ALBERTA
△ U.S.A. COAL COKED IN CANADA
ALL ANALYSES ON BASIS CARBON+HYDROGEN+OXYGEN=100
BASED ON DIAGRAM BY H.J. ROSE

Figure 2.

behaviour of the coal. Chemical analyses and small scale laboratory tests are always resorted to for preliminary investigations, especially to select the coals which warrant large scale study. The present investigation has not yet passed the laboratory stage, but it has gone far enough to show that there is little doubt that Alberta could supply the needs of a Canadian coke industry.

Box tests on six coals from the Crowsnest area were carried out for the Dominion Government in 1909, but as coke oven practice has been revolutionised during the past 18 years these tests are now obsolete.

Proximate Chemical Analyses.

A brief summary is given below of the tests made in the present investigation. The first tests made were proximate chemical analyses. Three samples of United States coals used in Canadian coke ovens were analysed for comparison. Whilst it cannot be certified that these are correct average samples, they are reasonably typical. Coals 401 and 400 were coked commercially in a blend of 80% and 20% respectively.

TABLE V.—AMERICAN COKING COALS.

Coal	401	400	Blend	407
Moisture ....%	1.6	0.6	1.2	1.2
Ash ....%	8.5	5.6	8.0	6.6
Volatile Matter ....%	33.4	17.6	30.0	33.5
Fixed Carbon ....%	56.5	76.2	60.8	58.7
Fuel Ratio	1.7	4.35	2.05	1.75

The ash content of these coals is low, but the average ash content of commercial shipments of Alberta bituminous coal has decreased during the past few years, and 4 coal washeries are now in operation. It should also be pointed out that the sulphur content of Alberta coals is low and the fusion temperature of the ash of the bituminous coals is high, both points of marked advantage in coal for making domestic coke. The volatile matter content of the United States coals is high, but Alberta has bituminous coal with over 30% volatile matter. The possibility of blending to increase volatile matter will be discussed later. Some 16 samples of coal in all were obtained for coking tests, and these, together with other samples, were analysed. Results of these analyses are given in Table V.

Ultimate Analyses.

Ultimate analyses also give an indication of the coking properties of coals. Mr. H. J. Rose, Assistant Chief Chemist of The Koppers Company, in a recent paper* discusses this subject at length. He gives a chart showing the carbon, hydrogen and oxygen content of 150 typical coking coals of the U.S.A. after the ultimate analysis has been reduced to a moisture, ash, sulphur and nitrogen free basis. This chart is reproduced in Figure 2, with the addition

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*Transaction A.I.M.M.E. Vol. LXXIV, 1926, pp. 600-636.

TABLE VI.—ANALYSIS OF COALS FOR COKING TESTS.

Coals	408	413	411	402	414	403	409	404	410	406	412	405
Proximate Analysis—Moist coal as received.												
Moisture ....%	7.4	5.0	1.4	1.2	1.4	0.9	1.0	0.9	0.7	0.7	0.8	1.0
Ash ....%	7.6	11.6	11.1	11.3	8.3	8.3	12.4	9.6	10.7	6.6	10.0	12.7
Volatile Matter ....%	37.9	37.0	29.7	29.1	27.9	26.7	25.0	24.6	24.2	22.7	20.0	16.4
Fixed Carbon %	47.1	46.4	57.8	58.4	62.4	64.1	61.6	64.9	64.4	70.0	69.2	69.9
Fuel Ratio	1.25	1.25	1.95	2.00	2.25	2.40	2.45	2.65	2.65	3.10	3.45	4.25
Ultimate Analysis—Dry Coal.												
Carbon	....	....	76.1	76.5	80.7	....	....	79.8	....	80.8	....	79.1
Hydrogen	....	....	4.8	4.3	4.8	....	....	4.5	....	4.4	....	4.1
Ash	....	....	11.2	11.4	8.4	....	....	9.7	....	6.7	....	12.8
Sulphur	....	....	0.5	0.5	0.3	....	....	0.5	....	0.5	....	0.5
Nitrogen	....	....	1.1	1.1	1.2	....	....	1.0	....	1.2	....	1.0
Oxygen	....	....	6.3	6.2	4.6	....	....	4.5	....	6.4	....	2.5
Ultimate Analysis—Pure Coal—C+H+O=100												
Carbon	....	....	88.4	89.1	90.4	....	....	90.9	....	88.9	....	93.7
Hydrogen	....	....	5.6	5.0	5.4	....	....	5.1	....	4.8	....	4.9
Oxygen	....	....	6.0	5.9	4.2	....	....	4.0	....	6.3	....	1.4

of points to represent the analyses of certain Alberta coals, and also the U.S. Coal, sample No. 407, the proximate analysis of which was given above. In calculating these Alberta analyses to a carbon+hydrogen+oxygen=100% basis, a slight modification of the formula used by Mr. Rose was employed. The difference is trivial. This chart shows at a glance the types of coking coals available amongst the samples tested.

Crucible Test.

In the determination of volatile matter one gram of coal is heated for 7 minutes in a platinum crucible at 950°C. The appearance of the button of coke left indicates the coking properties of the coal, although some coals which coke in this test cannot yet be coked commercially. Figure 3 is a photograph of 28 such buttons, arranged in order of ascending coke yield, which ranges from 58% to 82%. The 4 U.S.A. coals already referred to are included. with their numbers underlined. A key to the numbers follows:

KEY TO COKE SAMPLES IN FIGURE 3

	Coke yield.		Coke yield.
No. 1 Sample	58.1%	No. 15 85% 402 & 15% 405....	71.5%
No. 2 Sample, 413	58.1	No. 16 Sample 403	72.4
No. 3 Sample	58.3	No. 17 Sample 414	72.4
No. 4 Sample	64.3	No. 18 75% 402, 25% 405......	73.3
No. 5 Sample, 401	65.0	No. 19 85% 403, 15% 405......	74.2
No. 6 Sample, 407	65.3	No. 20 Sample 404	74.5
No. 7 Sample	66.9	No. 21 Sample	75.0
No. 8 75% 402, 25% 413......	67.3	No. 22 75% 403, 25% 405......	75.4
No. 9 85% 402, 15% 408......	67.9	No. 23 85% 404, 15% 405......	75.8
No. 10 85% 402, 15% 413......	68.3	No. 24 75% 404, 25% 405......	76.5
No. 11 80% 401, 20% 400......	68.9	No. 25 Sample 412	79.2
No. 12 Sample 411	69.4	No. 26 Sample 400	81.8
No. 13 95% 402, 5% 408........	69.6	No. 27 Sample 405	82.6
No. 14 Sample 402	69.7	No. 28 Sample 405	82.6

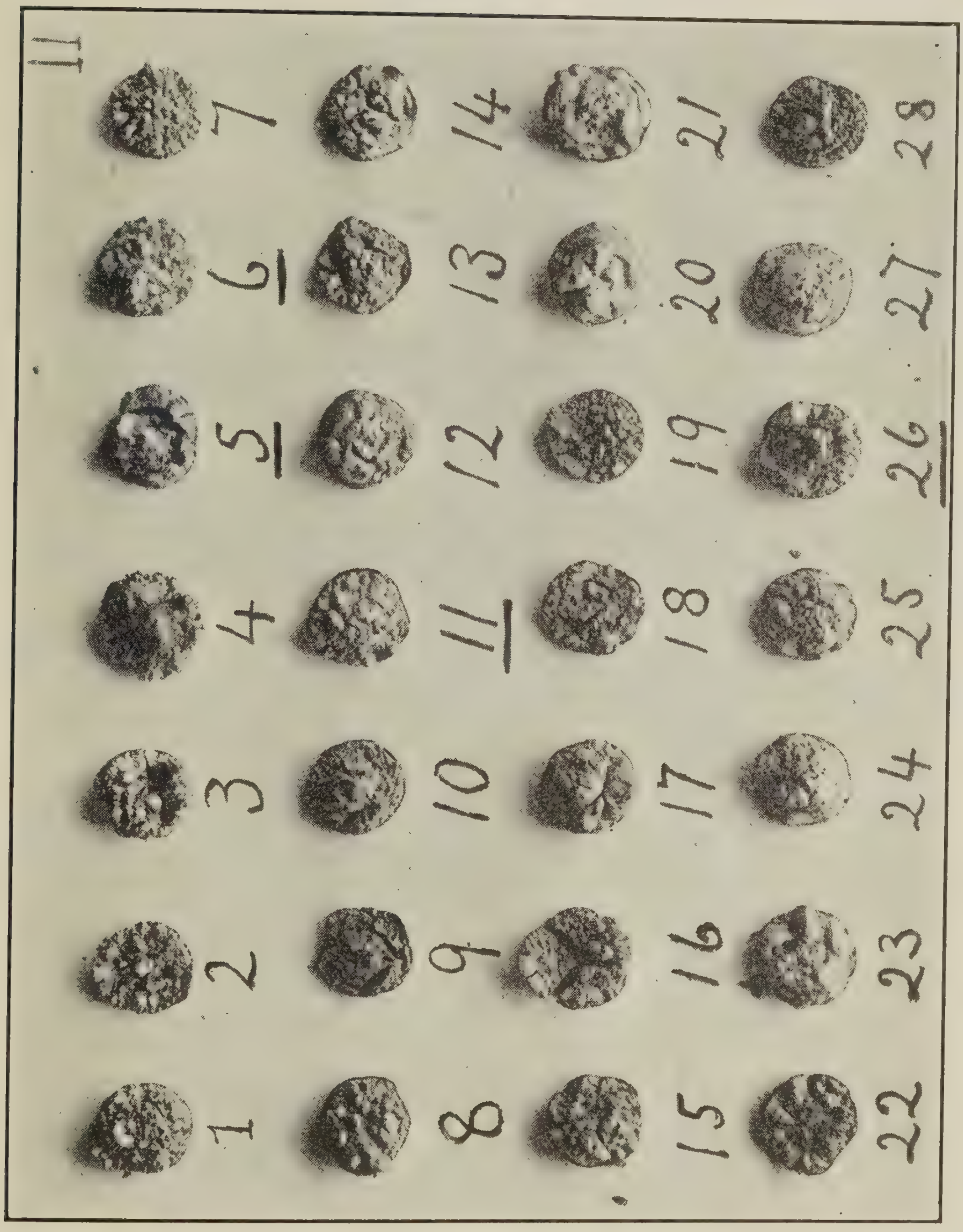

Figure 3.

The first four and the last four buttons are from coals usually regarded as outside the range of coking bituminous coals. The photograph does not do justice to the excellent quality of a number of the buttons shown.

Lessing Test.

R. Lessing has devised a test for coking coals in which the coal is coked under a quartz weight in a quartz tube. This gives not only a comparison of the cokes, but also the gas yields. A number of tests were made in this apparatus, but the method was abandoned in favour of the following test.

Tube Test.

H. J. Rose, in the paper quoted above, refers to a test in which a column of coal, equal in length to half the width of a coke oven, is heated by gradually advancing it into a furnace. In the adaption of this test employed, a 7″ column of coal is placed in a 1″ bore porcelain tube, and this is advanced into a tube furnace heated to 1000°C. The tube is advanced one-quarter inch every 15 minutes, so that about 7½ hours are required to complete the coking. The coke produced is weighed and examined, and the gas is measured. Some excellent cokes have been made with Alberta coals in this test and Figure 4 shows a few of the earlier samples. The gas yield with many of the coals is lower than with the U.S.A. coals tested for comparison, but the coke is denser and harder. If a larger gas yield is desired it has been found that this can be attained either by selecting one of the higher volatile, coking coals, or by blending with 10 to 20% of the high volatile coals verging on the sub-bituminous class.

Softening Temperature of Coal.

In an endeavour to ascertain the basic principle which allows only certain coals to coke, a study has been commenced of the softening temperature of coals and also of their decomposition temperatures. It is hoped that this will also serve as a guide to the best coals to blend when special qualities are desired. Good progress has been made, but this work is not yet ready for publication.

DOMESTIC FURNACES.

Little progress was made with the regular programme during the year, but one gas furnace and one fuel economizer were tested.

Sparks Patent Gas Furnace.

This furnace, patented by W. A. Sparks, of Edmonton, is designed for use as a pipe or pipeless hot air furnace to burn natural gas. No determinations were made of the heat transmitted to the heated air, or radiated from the furnace, but an estimate of the heat lost up the chimney was made from the analysis and temperature of the flue gases under different rates of operation and burner adjustments. The conclusion was arrived at that probably from 15 to 25% of the gross heat of the gas would normally be lost up the flue, according to the care taken in adjusting the burner. The over all efficiency of any such furnace varies with the installation.

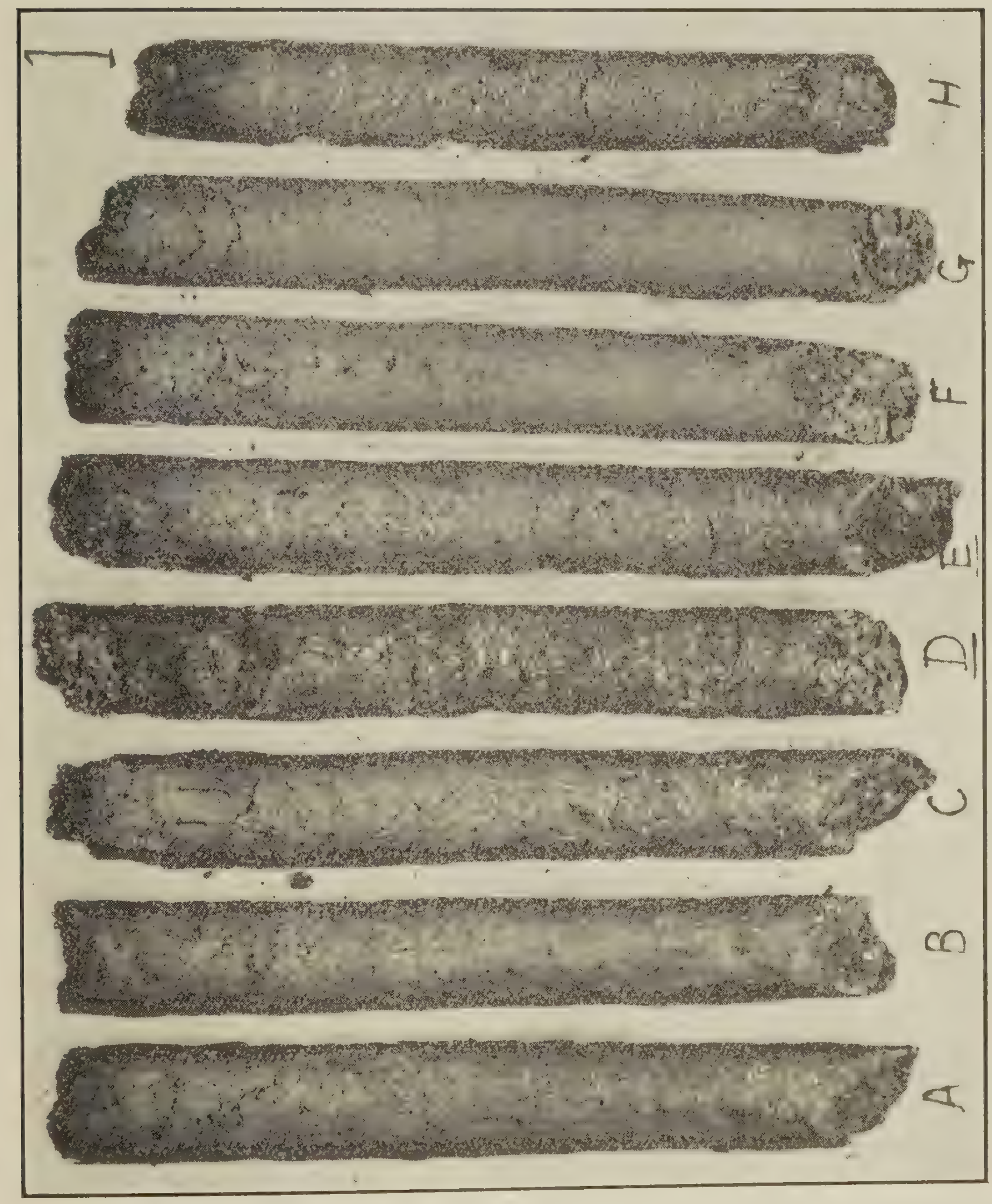

Figure 4.

Fuel Economizer.

A chemical preparation for the treatment of coal that was stated to increase the heat obtainable when lignite or bituminous coals are burned, was also tested. The material was largely soluble in water. A solution was prepared and the coal sprinkled before burning in such a way that the coal received a treatment equivalent to one pound per ton. A number of pairs of tests were run with Edmonton domestic coals in a Gurney hot water cottage heater. The total duration of the tests was 20 days. The furnace was fired three times daily for 18 of the days, and every hour for two days. No effort was made to attain high efficiency, but rather to copy ordinary household practice. On the other hand, in pairs of tests with untreated and treated coals respectively, every effort was made to duplicate conditions in the two tests of the pair. The average efficiency for eight days of untreated coal was 54.9% and for eight days of treated coal was 58.2%, an increase of 6% with treatment. No great accuracy can be claimed for these results, owing to the difficulty of maintaining uniformity of conditions, but they did show a fairly consistent increase of about the amount stated.

A film of water on the surface of coal when fired is often claimed to be notably beneficial; but as the chemical in question was not deliquescent, and the water in which it was dissolved evaporated before the coal was fired, water cannot have caused the effect noted. Dr. R. Lessing and others, however, have in the past few years noted some surprising effects in the carbonization of coal and the generation of gas due to the catalytic action of small amounts of different chemicals. The sample in question may have an action comparable with those studied by Dr. Lessing.

The tests made cannot be said to establish the commercial value of the product. No tests were made with bituminous coals nor in power plant furnaces, where a notably higher efficiency is normally obtained.

BRIQUETTING.

The briquetting investigations described in the previous Annual Reports were continued intermittently during the latter part of 1927.

During this period 94 batches of briquettes were made. Of these, 23 were made with bituminous coal; 38 with sub-bituminous; 13 with carbonized lignite; 2 with carbonized sub-bituminous; and 18 with blended coals. 23 batches were made with McMurray asphalt; 36 with other asphalts; 1 with hard coal tar pitch; 12 with starchy materials, and 22 with mixed binders. The McMurray asphalt was obtained by steam distillation of the bitumen separated from McMurray bituminous sand at the Dunvegan separation plant.

The small commercial roll press (Type Y 1, Mashek Engineering Company) installed in 1926, was operated during 1927.

Comparative tests made with this press and with the plunger press previously employed, gave the following information.

(1) The briquettes made with the roll press usually had the higher density. They also showed the higher loss in the rattler

test, but as the two types of presses gave briquettes of different size and shape, the results are not strictly comparable.

(2) The mixture to be briquetted had to be cooled to a lower temperature in order to make good briquettes with the roll press.

(3) Some batches could be readily pressed in the roll press that could not be handled in the plunger press, owing to difficulty caused by the material adhering to the plungers.

(4) In general the roll press was found to be less satisfactory for small scale, experimental tests, but its use ties up the work with commercial practice.

In previous work the difficulty was encountered of the mixture adhering to the plungers when briquettes were made without the addition of moisture. With the roll press it is possible to press such sticky material by spraying water upon the rolls during pressing.

During the past few years some apparently contradictory results have been obtained with regard to the advantage to be gained by the addition or presence of water in the different stages of the manufacture of briquettes. It appears, however, that the effects observed vary with the coal and with the binder.

Briquettes made from bituminous coal with asphalt as binder were of better quality when made without moisture. Such batches can be made with the roll press as stated. This procedure allows of a higher temperature of mixing, which is advantageous, but it is more difficult to cool the mixture rapidly from the mixing temperature to the desired temperature for pressing when water cannot be added.

Previous results indicated that briquettes with good firing properties could be made from a sub-bituminous coal, if it were blended with 10% of a good coking coal. During the year one sub-bituminous coal was tested which required blending with more than twice the above percentage of coking coal. This coal showed a marked tendency to swell when heated.

Unsuccessful attempts were made at the end of the year to prepare emulsions from the harder pitches and asphalts by means of a colloid mill. A sample of asphalt emulsion will be procured during the coming year and the use of this in briquetting will be studied.

All tests indicate that excellent briquettes which are both hard and waterproof can be made with starchy binders and McMurray bitumen. The latter can be added either in the crude condition or as an emulsion.

A process developed by T. Nagel of the American Cyanamide Company was tried. In this a binder is used composed of molasses, alcohol slops, sulphite pitch or causticized vegetable glue, etc., mixed with phosphoric acid. The briquettes require a heat treatment at 250-500°C to render them waterproof.

Von Delkeskamp and his co-workers have developed a process of colloidal briquetting, and proven it satisfactory for briquetting the brown coals of Germany. It consists of wet grinding a part of the coal until it becomes a stiff, slimy mass and then mixing this with the rest of the coal and briquetting. This requires only moderate pressures. The binding action is due to the colloidal nature of the slime. This process has been investigated, but so far without success, possibly because the coals tested contained less natural binding material than the German coals. The investigation is still in progress.

The work on the production of colloidal binders from straw, sawdust and other waste materials was continued during the year. A considerable quantity of lignite was carbonized and made available for briquetting tests.

TABLE VII.—BITUMINOUS COALS.

Run No.	Mixing Ratio and Binder		Rattler Loss	Specific Gravity		Voids %
				Apparent	Real	
		Canmore Coal.				
719	5	Asphalt No. 1	10.4	1.18	1.33	11.5
783	5	Asphalt No. 5	13.7	1.21	1.34	9.9
659	6	Asphalt No. 1	3.1	1.17	1.33	12.4
665	6	Asphalt No. 2	8.3	1.14	1.33	13.9
785	6	Asphalt No. 3	9.5	1.21	1.34	9.5
676	6	Asphalt No. 4	11.6	1.17	1.34	12.9
783	6	Asphalt No. 5	13.7	1.21	1.35	10.3
681	6	Asphalt No. 6	13.7	1.17	1.33	11.8
		Greenhill Coal.				
*816	4	Asphalt No. 7	13.0	1.207	......	......
*815	5	Asphalt No. 7	8.5	1.227	......	......
729	5	Asphalt No. 1	9.6	1.25	1.38	9.9
753	6	Asphalt No. 1	2.3	1.265	......	......
*814	6	Asphalt No. 7	6.0	1.238	......	......
*848	6	Asphalt No. 10	15.7	1.232	......	......
*813	7	Asphalt No. 7	5.0	1,237	......	......
266	7	Soft Coal Tar Pitch	15.8	......	......	......
708	1½	Flour.				
	4	Crude McMurray bitumen	2.9	1.246	1.415	11.9
707	2	Flour.				
	2	Crude McMurray bitumen	10.0	1.245	1.425	12.7
518	1½	Flour.				
	4	Soft Coal Tar Pitch	10.0	1.210	......	......
		McGillivray Greek Coal.				
791	6	Asphalt No. 3	6.6	1.250	1.388	10.0
795	6	Asphalt No. 8	7.5	1.252	1.383	9.5
793	6	Asphalt No. 5	8.7	1.241	1.386	10.5
792	6	Asphalt No. 9	9.9	1.245	1.382	9.9
801	6	Hard Coal Tar Pitch	19.9	1.219	1.400	13.0

*Roll press used for these runs.

TABLE VIII.—SUB-BITUMINOUS COALS.

Run No.	Mixing Ratio	Binder	Loss % Rattler	Specific Gravity		Voids %	Remarks
				Apparent	Real		
Coal Valley Coal.							
723	5	Asphalt No. 1...........	8.5	1.220	1.470	17.2	
758	6	Asphalt No. 1...........	4.2	1.30	1.460	10.7	
748	6	Asphalt No. 1...........	5.0	1.146	1.408	18.6	Washed coal
*809	6	Asphalt No. 7...........	12.5	1.224	....	......	
693	7	Asphalt No. 1...........	3.3	1.230	1.470	16.1	
*810	7	Asphalt No. 7...........	8.5	1.233	....	......	
749	7	Asphalt No. 1...........	4.0	1.151	1.408	18.3	Washed coal
750	8	Asphalt No. 1...........	1.7	1.168	1.408	18.3	
736	1½	Flour.					
	6	Crude McMurray Bitumen	1.4	1.260	1.460	13.9	
807	1	Flour.					
	4	Asphalt No. 1...........	6.1	1.240	1.473	15.8	
Coal Valley Coal 90% and McGillivray Creek 10%.							
630	5	Asphalt No. 1...........	5.3	1.250	1.490	15.9	
591	6	Asphalt No. 1...........	4.1	1.300	1.490	13.1	
786	6	Asphalt No. 3...........	10.6	1.236	1.460	15.3	
787	6	Asphalt No. 9...........	12.8	1.238	1.460	15.8	
Sterco Coal.							
332	1.5	Sawdust.					
	6.0	Asphalt No. 1...........	2.8	1.280	....	......	
331	1.6	Sawdust.					
	6	Soft Coal Tar Pitch..	6.4	1.320	....	......	
Sterco Coal 97% and McGillivray Creek 3%.							
492	8	Soft Coal Tar Pitch..	9.2	1.280	....	......	
497	1.6	Straw.					
	6	Soft Coal Tar Pitch..	7.6	1.250	....	......	
Sterco Coal 90% and McGillivray Creek 10%.							
559	6	Asphalt No. 1...........	5.2	1.230	1.460	15.6	
551	7	Asphalt No. 1...........	2.7	1.270	1.440	12.5	
519	1½	Flour.					
	6	Soft Coal Tar Pitch..	8.1	....	....	......	
Saunders Ridge Coal.							
821	5	Asphalt No. 7...........	6.3	1.128	....	......	
820	4	Asphalt No. 7...........	11.0	1.135	....	......	
Saunders Ridge Coal 75% and Greenhill 25%.							
*858	1½	Flour.					
	2	Asphalt No. 10..........	3.7	1.162	....	......	
*862	2	Starch.					
	1½	McMurray bitumen as emulsion	7.9	1.175	....	......	

*Roll press used for these runs.

In tables VI to IX, there are given some selected results obtained when certain coals were briquetted with various binders. The binders include several asphalts, two coal tar pitches and some miscellaneous mixed binders. All the briquettes are regarded to be of commercial quality with respect to handling and weathering properties, but those made with sub-bituminous coal without the addition of a coking coal would tend to distintegrate in the fire.

In these tables "Mixing Ratio of Binder" indicates the weight of binder added to 100 parts of coal. Thus, 5 Mixing ratio corresponds to 4.8% of binder in the briquette, 6 mixing ratio to 5.7% and 7 M.R. to 6.5%, and so on, assuming that no added water remains in the briquette. "Rattler Loss" gives the percentage loss in weight when 2 kilograms of the briquettes are given 200 revolutions in the standard rattler (see Annual Report for 1923, p. 35). "Apparent Specific Gravity" is determined by weighing the briquette in air and in water, without allowing the water to enter the pores of the briquette. "Real Specific Gravity" is determined by weighing the briquette in air, and in water after all air from the pores has been displaced, as far as posslble, by water by prolonged evacuation with an air pump. The percentage of "Voids" or air spaces in the briquette is calculated from the relation between real and apparent specific gravity. The briquettes were all made in the plunger press except those indicated which were made in the roll press. Canmore coal has been included under the heading "Bituminous Coals," although this coal approaches the anthracites in character. In the mixed binders, flour or other starch binder was converted into paste by treatment with steam or hot water either before or after mixing with the coal; straw and sawdust were always converted into a jelly-like paste before being added to the coal.

Table IX gives some physical constants of the bituminous binders referred to in the earlier tables. Melting points were determined by the ring and ball method. Ductilities are expressed as the extent, in centimeters, to which a test piece at 25°C could be elongated before it broke. Viscosities were determined at different temperatures in a Stormer Viscosimeter; the values are only relative, not absolute. Penetration gives the depth in tenths of millimeters that a weighted needle penetrates the bitumen in 5 seconds, when the bitumen is at the specified temperature. Both apparatus and procedure were in accord with A.S.T.M. specifications for all tests except that of viscosity.

FUSION TEMPERATURE OF COAL ASH.

In Report 14 of the Scientific and Industrial Research Council of Alberta, published in 1925, the results were given of tests made by Mr. A. G. Scroggie on 53 coal samples. The results included what are known as temperature of initial deformation, softening temperature and fluid temperature. This work was resumed during the year, and the ash from 19 coal samples tested. In the majority of the cases where the new samples came from mines or districts previously tested, the new results for the softening temperature showed a reasonably close comparison with the old results.

TABLE IX.—CARBONIZED COALS.

Run No.	Mixing Ratio	Binder	Rattler Loss %	Specific Gravity		Voids
				Apparent	Real	
Carbonised Lignite.						
895	10	Asphalt No. 1............	2.4	1.005		
*895	10	Asphalt No. 1............	4.4	1.034		
745	12	Asphalt No. 1............	4.6	1.043		
224	14	Lignite Pitch	23.3			
Carbonised Saunders Ridge.						
897	10	Asphalt No. 1...........	3.0	Below 1.0		
*897	10	Asphalt No. 1............	9.6	" 1.0		
896	10	Asphalt No. 10..........	15.6	" 1.0		

*Roll press used for these runs.

TABLE X.—PHYSICAL CONSTANTS OF BITUMINOUS BINDERS.

Binder	Melting Point °C	Ductility cms. 25°C	Viscosity				Penetration 0.1 mms. at 25°C	Specific Gravity 25/25°C
			125°C	130°C	150°C	170°C		
Asphalt No. 1............	63.4	8.0	....	280	84	33	23.0	1.054
Asphalt No. 2............	....	....	220	200	59	34	15.0	....
Asphalt No. 3............	55.0	....	....	....	....	....	19.0	....
*Asphalt No. 4............	....	....	....	....	132	57	16.0	....
Asphalt No. 5............	61.1	....	....	....	....	....	13.0	....
**Asphalt No. 6............	....	....	....	171	60	32	37.0	....
*Asphalt No. 7............	....	....	275	207	70	33	36.0	....
Asphalt No. 8............	65.0	....	....	....	....	....	10.0	....
Asphalt No. 9............	57.8	....	....	....	....	....	16.0	....
Asphalt No. 10..........	60.3	....	174	125	39	18	15.0	1.06
Soft Coal Tar Pitch..	54.0	100.0+	37	27	12	....	34.0	1.257
Hard Coal Tar Pitch	71.5	0.0	....	117	43	15	0.0	1.254
Lignite Pitch	49.0	75.0	....	....	....	....	23.0	1.108

*Asphalt obtained by steam distillation of crude McMurray bitumen extracted from McMurray bituminous sand.

**Asphalt obtained by steam distillation of Wainwright crude oil.

GEOLOGICAL SURVEY DIVISION

BY JOHN A. ALLAN.

INTRODUCTION.

The compilation of field and office data obtained in 1926, the preparation of reports and the editing of the same for publication required considerable time during the first six months of the year. Dr. R. L. Rutherford during the first three months completed Report No. 17, "Geology along Bow River between Cochrane and Kananaskis," which is accompanied by Map No. 12. He assisted in the office with various survey duties and in addition gave instruction in the Department of Geology.

Between the end of April and the end of October, Dr. Rutherford conducted field surveys in different parts of Alberta as described below. Dr. P. S. Warren, Associate Professor of Geology at the University of Alberta, rendered most valuable assistance and gave freely of his time in examining and determining palaeontological material obtained in the field. He also accompanied Dr. Rutherford on a study of the Moose mountain section along Elbow river and on the Mesozoic section along the Bow valley west of Kananaskis. His assistance in this work is duly acknowledged and deeply appreciated. L. S. Russell rendered valuable assistance in determining vertebrate fossils, chiefly from the Paskapoo rocks, and as field assistant to Dr. Rutherford. His assistance in the drafting room was also valuable and is acknowledged with thanks.

The drafting work was considerably greater than in 1926 and included the compilation of Geological Map No. 12 from field data, structure sections, diagrams and charts. The work was most efficiently carried out by Mr. O. Inkster, D.L.S. and A.L.S. A tracing of the North Saskatchewan river from Rocky Mountain House down to the 5th Meridian was compiled from aerial photographs taken under the direction of the Topographical Survey of Canada.

Correspondence relating to this division during the year amounted to approximately 900 letters received and sent out. The information requested was of the usual character on mineral resources. Seventy-two requests were for information on oil and gas; twenty-two requests were on coal. Other requests were related to gold, silver, platinum, mica, sulphur, salt, phosphate, bituminous sand, bentonite, clays, marl, magnesium limestone, volcanic ash, abrasives, building gravel and water supply.

Many specimens of ores, minerals, rocks, clays and fossils were received and examined. These came principally from Alberta and the North-West Territories, but a few were from British Columbia, Saskatchewan and Manitoba. The samples requiring chemical analysis were forwarded to Mr. J. A. Kelso, Director of the Industrial Laboratories of the University.

Three sets of exhibit samples of the various oils found in Alberta were prepared for Mr. Howard Stutchbury, Alberta Trade Commissioner, and one set for the Department of Natural Resources, Canadian National Railway, Edmonton. During the summer a visit was made to some of the producing wells to obtain samples of oil. A five-gallon sample was received from the Home Oil Company in Turner Valley.

The fossils and also the mineral and rock specimens collected on the field surveys have been determined, classified and stored with previous collections in the Department of Geology at the University of Alberta.

A most valuable and unique specimen found during the year is a slab of Paskapoo sandstone containing the fossilized footprints of an early Tertiary mammal. This valuable specimen was discovered by Dr. Rutherford and his assistant, L. S. Russell, on the south bank of Red Deer river about a mile west of the town of Red Deer. This specimen has been prepared and suitably mounted in a frame for exhibit purposes. A short description of these mammal tracks has been prepared by the discoverers and published in the American Journal of Science. This is the first specimen of early Tertiary mammal tracks found in Canada and the animal that made the tracks was one of the earliest ancestors of the modern mammals.

This unique specimen has been presented by the Research Council to the University of Alberta for the Palaeontological Museum.

PUBLICATIONS FROM THE DIVISION IN 1927.

Report No. 17, "Geology along Bow River between Cochrane and Kananaskis" and accompanying Map No. 12, by Dr. R. L. Rutherford.

There is a close co-operation between this division and Dr. F. A. Wyatt of the Soils Department. On two former occasions reports were prepared on the surface geology of the Macleod and Medicine Hat sheets and each of these reports appears as an appendix to the Soils Survey report of these sheets prepared by Dr. F. A. Wyatt and Dr. J. D. Newton, and published by the College of Agriculture, University of Alberta. During the past year Dr. Allan prepared a report of a similar character on the Sounding Creek sheet. This report is entitled "The Relation of the Geology to the Soils in the Sounding Creek Sheet," and has been published as an appendix to the Soils Survey Report, Bulletin No. 16, of the same body.

PUBLICATIONS RECEIVED, 1927.

Memoirs and maps from H. M. Geological Survey, England, are acknowledged in exchange for publications of the Research Council. Reports, bulletins, etc., have also been received from the Mineral Resources Department, Imperial Institute, London; New South Wales and Victoria Geological Surveys; from Federal, Provincial and State Geological Surveys and Departments of Mines; and from several Universities.

FIELD INVESTIGATIONS.

Various districts in different parts of Alberta were visited during the year, and brief notes are given below on most of the districts examined.

Lethbridge and Crowsnest Pass.

Dr. Allan and Dr. Rutherford accompanied the field trip for the mining engineering and geological students from the University of Alberta. The Galt mine at Lethbridge and the North American Collieries at Kipp were visited. Data were obtained on the character of the coal seams being mined and on several of the minor faults and slips that occur in these seams. The coal seam mined here averages from four to about four and one-half feet. This seam occurs at the top of the Belly River formation and close to the contact with overlying Bearpaw marine shales. The stratigraphic succession was examined in this district and several fossils collected.

In the Crowsnest district the properties of the International Coal and Coke Company and the McGillivray Creek Coal Company were visited. The Cretaceous section as exposed in Crowsnest Pass was studied for the purpose of comparing it with sections examined farther north in the foothills. Fossils were collected from definite horizons in the Mesozoic strata and specimens were obtained from the Crowsnest volcanics that are well exposed in the vicinity of Coleman. The structural relations of the Kootenay strata throughout the Crowsnest Pass were also examined. Special attention was given to a field study of the phosphate horizon that occurs in Crowsnest Pass near Crowsnest Lake, and to the same horizon which is exposed in the vicinity of Fernie. This phosphate horizon has been traced by the Consolidated Mining and Smelting Company of Canada and the commercial possibilities of these deposits are now being investigated by this company. The same phosphate horizon is known to occur within the eastern ranges of the mountains in Alberta. These mineral deposits may be of considerable value to the province of Alberta at a later date.

Foothills District South of Bow River.

In May Dr. Rutherford and Dr. Warren examined the geological section where it is exposed toward the south end of Moose mountain along Elbow river. Much valuable information was obtained on the relation between the Mesozoic and Upper Palaeozoic formations which has an important bearing on the geology throughout the foothills belt. An examination of a similar section to determine the same stratigraphic relations was made in the Minnewanka region northeast of Banff. Dr. Allan and Dr. Rutherford made further observations on the foothills structure from the Bow river south to Sheep river. It is only by extending field investigations on the geological succession within the foothills that it is possible to determine with any degree of accuracy the stratigraphic succession as it occurs in any particular district. More extended studies of a general character will have to be carried on in various parts of the province before the necessary information on the mineral resources of Alberta can be obtained.

Red Deer District.

Dr. Rutherford examined the section of the Paskapoo strata exposed along the valley of Red Deer river from the mouth of Blindman river up to a point west of Innisfail. It was at this time that a unique fossil specimen of mammal footprints was discovered. The section along the North Saskatchewan between Rocky Mountain House and Horburg was re-examined. A general correlation of the Upper Cretaceous and Tertiary rocks was the principal object of these field surveys.

District West of Edmonton.

The Saskatchewan River section was examined from Edmonton upstream to the mouth of the Brazeau river. This survey of the geology connects with the work carried out in 1926. Several points along Pembina and McLeod rivers were re-examined in an attempt to determine the position of the top of the Edmonton formation and to correlate the coal seams occurring in this district.

A considerable portion of the Edmonton and Peace Hills sheets was traversed for the purpose of correlating the coal seams, determining the relative position and continuity of the seams and the relation of the coal in the Edmonton formation to the coal now being mined within the eastern edge of the foothills belt.

A report which embodies the results obtained during parts of 1926 and 1927 has been prepared by Dr. Rutherford and is ready for publication. The area covered in this report lies between the foothills and the plains of central Alberta. The information that will be contained in this report is of considearble value because it is believed that a correlation of the coal seams in the foothills with those under the plains in this part of Alberta has been accomplished. Dr. Rutherford has given special attention to a determination of the stratigraphic position of the thick coal seams which outcrop along the valley of the Saskatchewan river west of Edmonton and on the Pembina river near Evansburg, and the correlation of these thick seams with the coal that occurs along the Alberta Coal Branch in the outer foothills. The thickest seam which was observed on the North Saskatchewan river is about twenty-five feet.

The chief economic mineral products in this area include coal, building stone, placers and road material.

In all field examinations attention is always given to the occurrence of gravel suitable for road surfacing.

The search for placer gold has increased during the past few years and one company, the McLeod River Mining Corporation, Limited, is beginning operations on the recovery of gold from the gravels in McLeod river. In surveying this district the possible source of the gold has received special attention.

Rochester Coal Area.

A reconnaissance was made by Dr. Allan and Dr. Rutherford of the geology of the Rochester Coal Area and north to Athabaska. The traverse was confined chiefly to the Tawatinaw river from

Nestor to Athabaska. The occurrence of coal in the vicinity of Rochester was investigated. The coal occurs in the Belly River formation, but where observed the seams are thin and dirty. Mining on a very small scale has been carried out in the vicinity of Rochester, but operations have ceased. The extensive sand deposits in the vicinity of Rochester were examined. Sand from these deposits is used extensively by the building trades in Edmonton. This survey determined the approximate line of contact between the Edmonton and Belly River formations. Strata belonging to the Edmonton formation were found to extend as far north as Redwater river. Fuller details on the geology of this district will be given in a later report.

Grande Prairie District.

In September a preliminary survey was made of the district in the vicinity of Grande Prairie. The object was to investigate the coal occurrence in the Halcourt, Sexsmith and Valhalla Coal Areas and to obtain data on the general geological conditions in these areas, with particular reference to the possible distribution of coal, oil, gas, and water for domestic consumption.

The chief coal horizon occurs in the Wapiti formation which is approximately equivalent in age to the Belly River. Coal is being mined on Red Willow creek south of Halcourt. The coal seam averages from thirty to thirty-six inches in thickness with a sandstone roof and shale floor. There are several bands of "bone" in some places which reduce the thickness of the clean coal. In other parts of the seam there are about three feet of clean coal with "bone" bands at the top and bottom of the seam. Representative samples were taken of the coal seam at two points about one-quarter of a mile apart in adjoining legal subdivisions. The following analyses were made from these samples by the fuels division.

Lab. Sample No. 71-27.

Red Willow Mine No. 1134 operated by Mr. A. C. Schannell, in legal subdivision 2, section 21, township 70 range 10, west of the 6th meridian. This sample was taken from the face which was one month old.

	As Received.	Air Dried.	Dried.
Moisture ....%	9.7	9.0	....
Ash ....%	5.1	5.1	5.6
Volatile Matter ....%	34.6	34.9	38.4
Fixed Carbon ....%	50.6	51.0	56.0
Calorific Value, gross B.T.U. per lb.	11,900	11,990	13,180
Fuel Ratio	....	1.45	....
Coking Properties		Non-coking.	

Lab. Sample No. 72-27.

From the face of a new entry being opened by Messrs. Dunbar and Beatty in legal subdivision 7, section 21, township 70, range 10, west of the 6th meridian.

	As Received.	Air Dried.	Dried.
Moisture ....%	10.1	9.0	....
Ash ....%	5.0	5.1	5.6
Volatile Matter ....%	35.4	35.8	39.4
Fixed Carbon ....%	49.5	50.1	55.0
Calorific Value, gross B.T.U. per lb.	11,940	12,080	13,280
Fuel Ratio	....	1.40	....
Coking Properties		Non-coking.	

A point of special geological interest not previously noted is the occurrence of beds of possibly Edmonton age in the Kleskun hills north-east of Grande Prairie. These beds are quite similar in character and lithology to the Edmonton strata which occurs throughout central Alberta. Thin coal seams also occur within the strata in Kleskun hills, but no workable seams were observed. Some of the beds in this formation have a high bentonitic content. The presence of bentonite in the soil has an influence on the productivity. It is believed that when a detailed soil survey has been made of this district indications of other occurrences of strata of the same age will be found. A detailed report on the geology of this district will necessitate more extended field investigations.

Milk River District.

Reconnaissance surveys were carried out by Dr. Allan in the southern part of the province from range 10 west to Cardston. Information on the structural geology and the stratigraphic succession of formations was obtained along Milk river from the International boundary north to Etzikom and Chin coulees. Special attention was given to the structure on which the Rogers-Imperial gas well is located. This well has a reported capacity of 60 million cubic feet of gas per day. The relation of the Tertiary and Upper Cretaceous formations in the Milk River ridge and as far west as Cardston was considered. Geological observations were also made along the valley of St. Mary's river north of Cardston and along Oldman river west of Pincher Creek.

ROAD MATERIALS DIVISION

By K. A. Clark.

During the season of 1927 the study of the application to road work of bitumen separated from bituminous sands was continued, and a small experimental road construction project was carried through. Approximately fifty barrels of bitumen, separated in 1925 and held in reserve, were used for the work. The bitumen was emulsified in water and mixed in this form, with gravel. The gravel-emulsion mixture was laid on a 600-foot section of the St. Albert Trail highway about three-quarters of a mile beyond the northern limit of the city of Edmonton. The treated gravel showed remarkable packing properties and consolidated at once to a serviceable road. The surface was smooth and well bound and displayed the general characteristics of bituminous treated gravel. It withstood traffic through a wet fall.

The results indicate that it is practicable to surface treat gravel roads with the heavy viscous oil of the bituminous sands, and that such treatment will be no more costly than the well known surface treatment with more fluid and more easily handled oils. Because of the greater bonding power of the heavy, native bitumen, appreciably better results may be expected.

There is evident need of bituminous treated roads in Alberta and the other western provinces, and a large market for road oil is bound to open up during the next few years. Material for the purpose may be imported or may be obtained as a by-product from domestic oil refineries. The bituminous sands are another potential source of this material. The road construction project of 1927 forms a part of the systematic study of the Research Council of how the oil in the bituminous sands can be made available for this purpose.

Bituminous Treatment of Gravel Roads.

The building of gravel roads, even in a province like Alberta where gravel is comparatively scarce, is the most straightforward and the least costly of the well-known types of construction for all-weather highways. Seventy-five per cent. of the surface roads built in the Dominion under the terms of the Canada Highways Act were gravel roads.[1] Pavements costing tens of thousands of dollars per mile cannot be afforded for the accommodation of a traffic of a few hundred vehicles a day. Neither is it economical to allow traffic which has grown to this volume to struggle through mud. Experience throughout America has led to the general conclusion that the gravel road, costing a few thousand dollars per mile is the first stage of the solution of the all-weather road problem.

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[1] Annual Report of the Commissioner of Highways, Dept. of Railways & Canals, Ottawa. Bul. 10, 1927. Table III, p. 9.

The gravel road has the virtue of low initial cost; but has disadvantages. The principal one is that the gravel wears out, especially under the action of automobiles, and disappears from the road surface. A number of Western States that have investigated this point have estimated that from two to five hundred vehicles a day using a road will wear off from one to one and one-half inches of gravel per year.[2] The constant loss of material causes dust, makes the road surface rough, and represents a large loss of investment in gravel.

Treatment of the surface with some form of oil is the general procedure that has been adopted to overcome these disadvantages. Such treatment increases the cost of the gravel road, but improves its quality. It stops, to a large extent, the loss of material from the surface, and in proportion to the degree to which this is accomplished, the problems of dust, roughness and loss of investment in gravel are overcome. The cost of treatment is more than made up by savings in maintenance and replacement of material. Further, such treatment of the relatively low priced gravel road makes it possible to give adequate road facilities to larger volumes of traffic.

The simplest form of treatment consists of spraying the gravel road surface with a light fluid oil. Before oiling, the surface is made smooth and free of dust. About one-third of a gallon of oil per square yard of surface is applied by a distributor. The oil soaks into the gravel and, as long as the effect lasts, the oil prevents dust from flying and helps to keep the surface smooth. It supplies little actual bonding of mineral particles. This dust-laying operation must be done at least once a season.

Heavier oils have to be used to cement together the gravel particles of the road surface, as well as to lay dust, and many varieties of asphaltic road oils and coal tar preparations have come into use for this purpose. These oils are applied in much the same way as are the light oils used for dust laying; but as they do not soak into the gravel nearly so readily, a sprinkling of fresh gravel is spread over the oily surface. The final result is a road surface with a thin mat of gravel firmly bonded by the bituminous material. This mat resists the action of weather and traffic, and so long as it persists intact it gives a dust-free road with excellent riding qualities. By vigilant maintenance, this form of treatment will last for three years or more, if the traffic on it is not too large.

The preservation of a very thin bituminous surface mat becomes a difficult matter if traffic grows to considerable volume. Increase in the thickness of the treatment is being accomplished by loosening the surface of the gravel road to the depth to which treatment is desired, say two inches, and mixing in a suitable asphaltic oil or tar. The oil is applied from a distributor, and oil and loose gravel are mixed together by being rolled about on the road surface by a grader blade. When mixing is complete, the oiled gravel is spread out to proper shape and allowed to pack under traffic.

It is difficult to give costs for the various forms of bituminous treatments as they depend on the cost of road oil in any given section of the country. Localities within easy reach of oil refining centres can be supplied with suitable oil at reasonable figures. For dust laying, from 1,000 to 3,000 gallons of oil per mile are required, and the cost of treatment is largely the cost of the oil. For making a bituminous surface mat, from 5,000 to 7,000 gallons of oil per mile are used; but in addition to the cost of the oil applied, there is a considerable expense in carefully preparing the surface to receive the oil and in covering the oiled surface over with additional gravel. For mixing oil into a considerable depth of gravel surface 15,000 gallons, or more, of oil are used per mile, to the cost of which must be added the expense of manipulating the oil and gravel mixture with a grader outfit to get the mixing effect. The costs of the three types of treatment in sections of the United States where the methods have been used largely are of the general order of $300.00, $900.00 and $1,300.00 per mile respectively.

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[2] Light Asphaltic Oil Road Surfaces. C. L. McKesson and W. N. Frickstad. Public Roads, Sept. 1927, p. 128.

Sources of Supply of Road Oil in Alberta.

Alberta has adopted the policy of building gravelled roads, and some hundreds of miles already have been built. The problem of maintenance arises and the availability of road oils naturally must be considered. At the moment, there is no actual source of supply within the province, although there are several potential ones.

Most road oils used come from oil refineries. They may be just residual oil as sold for fuel or they may be blends of different grades of oil so combined as to yield a product meeting a road oil specification. The market for road oil provides an outlet for the less valuable refinery oils. Since there has been no market in Alberta so far, the refineries here have not concerned themselves with road oil. In all probability they will make and market such oil as soon as there is a demand, and probably a large proportion of the supply will come from that source.

Another possible source of road oil is the Alberta bituminous sands, and these are being given careful consideration.

Road Oil from Bituminous Sands.

The bitumen content of the bituminous sands cannot be used as a road oil unless it is separated from the sand. The problem of separation has been studied intensively by the Research Council and a successful process developed. The Council operated a separation plant of semi-commercial size during 1925 and separated the oil successfully from some 500 tons of bituminous sand. If a commercial company were to undertake development, it need not encounter undue difficulty in separating the oil from the sands.

The next problem is the adaptation of the bitumen from the bituminous sand as a road oil. In the types of treatment of gravel roads which have been developed and which have been described above, a fairly fluid oil is used. The oil must be fluid enough, at least when moderately heated, to spray easily through the nozzles of oil distributors and so either soak into the gravel or spread over gravel particles when the oil and gravel are mixed on the surface of the road. The bitumen from the bituminous sand is rather too viscous to do this, although its more substantial body and stickiness make it a very desirable bonding material to put into the road. Some modifications of the procedure developed for the use of more fluid oils is needed to overcome the difficulty of handling it and at the same time to secure the advantage of its excellent bonding properties.

Experimental Work with Bituminous Sand Oil.

The Research Council during the 1927 season constructed a short stretch of experimental road to test one method of using the bitumen or heavy viscous oil from the bituminous sands for treatment of gravel roads. The bitumen was emulsified with water in order to overcome the difficulty of handling a viscous material. By emulsification, any degree of fluidity at ordinary outside temperatures can be obtained. The emulsion and gravel, without heating, were mixed together in a simple concrete mixer. The physical properties of the gravel-emulsion mixture were such that it could be hauled to, and dumped on, the road by trucks and spread with a grader in the same way that ordinary gravel is handled. When the water had evaporated from the emulsion there was left a bitumen-treated gravel road similar to that obtained by the surface mixing method already described. The difference was the bitumen present had better body and cementing power than those possessed by oils ordinarily used for bituminous treatments.

The Research Council built a separation plant several years ago at the Dunvegan Yards, near the northern outskirt of the City of Edmonton, that provided handy facilities for the experimental road work. The preparation of the bituminous emulsion and the mixing of gravel and emulsion were done at the plant, and the treated gravel was put on a 600-foot section of roadway on the St. Albert trail, about 1½ miles away. The section treated was in a dirt grade built up to main highway specification and well compacted. It had been experimentally treated with Wainwright crude oil in 1925, but since that treatment had produced very little effect of stabilizing the clay soil, the section was representative of an ordinary well graded earth road.

The bitumen used was separated from bituminous sand in 1925.[3] About fifty barrels of the bitumen produced had been reserved for maintenance of the bituminized earth road built that year. This material was still on hand, and it was decided to use it for the gravel road experiment instead of for the purpose for which it was originally intended. This separated bitumen had the following approximate composition:

Bitumen	65%
Water	28%
Mineral Matter	7%

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[3] Sixth Annual Report, Scientific & Industrial Research Council of Alberta, 1925, p. 47.

The gravel used came from Rochester, Alberta. The following screen analysis indicates its grading (Standard Tyler sieves):

Retained on 1″ Screen	4%
“ “ ¾″ “	8%
“ “ ½″ “	12%
“ “ 4 Mesh Sieve	26%
“ “ 8 “ “	43%
“ “ 14 “ “	64%
“ “ 28 “ “	84%
“ “ 48 “ “	97%
“ “ 100 “ “	98%
“ “ 200 “ “	99%
Passing 200 “ “	1%

This was really a very coarse sand rather than a gravel. The only other gravel readily available was a very coarse one containing a large amount of stone greater than 1½ inch in diameter.

A laboratory size Premier colloid mill was used in making the emulsion, and rosin soap and potato starch were used as stabilizing agents. The emulsion had the following composition:

Bitumen	45%
Water	48%
Mineral Matter	4%
Stabilizers	3%

The gravel and emulsion were mixed in a concrete mixer. The quantity of emulsion added to each batch of gravel in the mixer was calculated to give a bitumen content of 3% to the mixture when dried. In actual result the bitumen content was found to be about 2¾%.

The making of the emulsion in the laboratory, colloid mill was a slow operation, consequently the other operations of the work had to be accommodated to it. When enough emulsion had accumulated to mix with a carload or so of gravel, the mixture was made and placed in storage in a bin.

When all the bitumen had been emulsified and mixed with gravel, preparations were made to place the gravel mixture on the road. The Public Works Department sent a power maintenance scarifier and grader to the road site. The earth surface was torn up to a small depth and smoothed out by the grader to a flat cross section. The bituminized gravel was loaded into trucks by a steam grab bucket, hauled to the road and dumped in a windrow down the centre of it. Enough material was placed along a given length of roadway to spread out twenty feet wide to a depth of four inches in the center, tapering to three inches at the sides. When all the gravel had been deposited in the windrow, the grader spread it out to the desired width and smooth cross section.

The gravel-emulsion mixture packed at once to a solid road bed. Traffic was not interfered with during the spreading operation. As the grader was pushing the gravel out from the windrow, vehicles were passing and running over the material. By the time it was properly distributed cars and trucks were riding right up on its surface and making very little impression on it. So long as water remained, the bituminized gravel surface could be worked. The grader stood by for a few days and kept the surface smooth and well shaped. In a short time the water evaporated and the gravel bed became quite rigid and finely bonded.

This experimental section stood up well during the remainder of the season, during which there was a great deal of wet weather. Traffic picked up mud from the clay road on either end of the short stretch of treated gravel and dropped it over the surface, but the gravel itself did not suffer to any extent. The two and three-quarter per cent. of bitumen in the open-textured gravel was not enough to give a tightly sealed surface. The result was that water entered it to a depth of about a quarter of an inch, but a firm road surface was always presented.

Possibilities and Problems of Emulsions for Gravel Treatment.

The work of the past season was a preliminary experiment in the general study of how the bituminous sand oil can be adapted to gravel road treatment. As an experiment, the project was a success. Nothing was encountered in carrying out the work to indicate that the general procedure is not thoroughly practical. Gravel, whether damp or dry, mixes easily with the emulsion in simple mixing devices and without heating. The gravel containing the emulsion can be handled in the same way as ordinary gravel, that is to say, it can be loaded into and dumped from trucks and moved about the road surface with graders just as these operations are done with gravel in ordinary road work. Further experiments will probably indicate a more suitable grade of gravel and a better proportion of bitumen than those tried. Experience will also show what depth of treated gravel should be placed on the road and whether it should be put directly on the dirt base or on a foundation of compacted gravel. The promising behaviour of the experimental road indicates that the general scheme has useful possibilities.

The use of emulsions is not an innovation. Asphalt emulsions are becoming well established for pavement repair work and even for new pavement construction, but the present experiment is probably among the first trials of them for bituminous gravel road treatment.

Emulsification promises to provide a neat way of adapting the bitumen from the bituminous sand to road work. Separation by the hot water process appears to be the best way of winning the bitumen from the bituminous sands, but this process gives a crude product containing water. Improvements in the process will in all probability yield a separated oil with a much lower water content than that produced in 1925 in the separation plant. Nevertheless, there will be some content of water. To produce a dry oil would necessitate a refining operation and additional cost. The water content is no detriment, however, if the separated oil is emulsified. The advantage of the emulsion in rendering the oil fluid and readily mixable with gravel at ordinary temperatures has been pointed out already.

In bituminous treatment work as generally practiced, the oil is applied to the gravel where it lies on the surface of the road. In the case of the experiment under discussion, the gravel and oil were mixed before going to the road. This is different from the ordinary procedure, but it is worth considering whether it may not be an advantageous change well suited to conditions as they exist in Alberta. Gravel road construction is just commencing in this province. Where the gravel is still in the pits, it should be just as cheap and probably cheaper to do the mixing in a convenient mixing machine rather than when the gravel is spread over the surface. The probability of getting the desired proportion of oil uniformly mixed into the gravel is much better in the case of the mixing machine.

The cost of large scale work along the line of the experiment is anticipated to be about the same as the cost of bituminous treatment by the grader mixing method referred to on page 43. The items of expense other than the oil used are comparable in both methods. No road oil has been offered to the Alberta market yet, so it is not possible to say exactly what it will cost, and all that can be said about bituminous sand oil is that it must compete in cost with road oils from other sources if it is to win a place in the market, and the indications are that it can compete.[4] The cost of the treatment probably will be less than $2,000.00 per mile.

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[4] Bituminous Sands of Alberta, Part II, K. A. Clark & S. M. Blair, Report 18, S. & I.R.C.A., 1927, p. 29.

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